Economic Cost of St. Louis Encephalitis Epidemic in Dallas, Texas, 1966

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PUBLIC HEALTH officials are increasingly becoming more aware of the usefulness of economic analysis as an additional tool for decision making, budgetary support, and planning. To further demonstrate the applicability of economic analysis for examining health problems and, hopefully, to stimulate increased collection of economic data necessary for future analyses, the following study was initiated in fall 1966. This analysis is chiefly concerned with using economic concepts and methodology to provide an economic dimension when studying an epidemic situation.

Beginning in late July 1966, the city of Dallas, Tex., experienced a major epidemic of St. Louis encephalitis (SLE). The first confirmation of a case of SLE was made by the Texas State Department of Health on August 9. As of November 22, 1966, the health department and the National Communicable Disease Center had determined serologically that 172 persons had been infected by the virus during the epidemic (31.7 percent of the 542 suspect cases reported). Twenty deaths were attributed to encephalitis by NCDC epidemiologists. Six other deaths occurred, but they were not directly attributable to the epidemic.

Each suspect case was classified serologically as confirmed, presumptive, inconclusive, negative, or pending, and clinically identified as either encephalitis, aseptic meningitis, febrile headache, or other. In estimating the cost of the SLE epidemic, only the 172 cases serologically classified as confirmed or presumptive were examined and these cases were subdivided in this study as encephalitis (131) or "other" (41).

The estimated cost of the epidemic and of related control activities was $796,500.

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Definitions and Methodology

In economic terminology, "economic costs" include both direct and indirect costs. Direct costs estimated in this analysis are actual outlays made by individuals, employers, and government agencies to control the epidemic and treat the patients. Data for this estimate were derived from epidemic reports, hospital records, and conferences with epidemic investigators.

Unlike direct costs, indirect costs represent not dollars spent for goods or services, but the value of output lost when a person cannot work because of illness (morbidity cost) or ceases to be productive because of death (mortality cost). Lost output is measured by estimating earnings foregone because of sickness and death. The method used to estimate these losses is similar to that used by Rice and Weisbrod (*1, 2*).

For mortality losses, estimated future earnings are discounted to determine the present value of the earnings. As stated by McCullough (*3*):

Money invested at some rate of interest will increase in value over time. For example, $100 invested today at 6 percent interest will amount to $106 one year from now. Looking at it in another way, $106 one year in the future is worth only $100 at the present, if money is worth 6 percent. The sum $100 is called the *present value* of $106, one year in the future if money is worth 6 percent. The $106 is *discounted* at 6 percent to determine the present value.

Major cost estimates presented in the analysis are for epidemic control ($348,500), patient treatment ($196,100), morbidity ($82,800), and mortality ($169,100). The epidemic's broader impact upon the Dallas economy is also considered.

Control Expenditures

Estimated costs of epidemic control were classified by the the following activities: vector control, laboratory support and epidemiologic aid, administrative and clerical activities, and information and communication services (table 1).

Vector control included both land and aerial spraying. When the encephalitis vector was identified as *Culex quinquefasciatus*, participating government officials decided to supplement land spraying operations with ultra-low-volume aerial spraying (*4*). This was the first time this aerial technique had been used to combat a vectorborne epidemic in an urban setting. Six specially equipped U.S. Air Force C123 airplanes sprayed on 9 consecutive days, beginning August 19. Of the estimated $198,800 spent for vector control, approximately $103,000 was for chemicals used in aerial and ground spraying activities. Approximately 12,000 gallons of a high-concentration, low-volume malathion mist were used for aerial spraying operations.

Mosquito identification was used during the epidemic to determine the vector transmitting the virus, measure the level of viral infection within the vector, and evaluate the effectiveness of aerial spraying. Cost estimates of laboratory support also include the cost of processing human serum, viral isolation studies, and tests performed on patients hospitalized during the epidemic. These tests were part of structured protocols used by several Dallas hospitals in research studies. Primary epidemiologic activities were casefinding, serologic surveys, and data interpretation. Unlike laboratory support costs, most of the costs for epidemiologic activities were for personnel.

Other major control-related costs were for administrative, clerical, information, and communication services. Cost estimates were made of overhead allocations to obtain most of the estimated expenditures for administrative and clerical expenses. Publicity and general communications included daily meetings of key participants and establishment of a central information center and a hospital surveillance system. The cost of a television documentary film on the epidemic, produced by a Dallas television station, is also included in the estimate.

Table 1 also presents investigation and control costs, by major participants. Because of a suspected causal relationship between the 1966 spring floods in Dallas and the occurrence of the epidemic, the Office of Emergency Planning reimbursed the Dallas City Health Department for most of its epidemic-related costs.

Treatment Costs

Costs of treating patients included hospital and physician charges as well as drug use and related nursing home and nursing care services.

Table 1. Estimated control costs, 1966 St. Louis encephalitis epidemic in Dallas, by control activities and major participants

Activities and participants	Estimated cost (total=$348,500)	Percent
Activities		
Vector control	$198,800	57.1
Laboratory support and epidemiologic aid	103,200	29.6
Administrative and clerical	30,000	8.6
Information and communication services	16,500	4.7
Participants		
Dallas City Health Department	[1] 172,700	49.6
Dallas County Health Department	16,000	4.6
Texas State Department of Health	[2] 4,000	1.1
National Communicable Disease Center	67,800	19.5
U.S. Air Force	31,400	9.0
Other	56,600	16.2

[1] Includes $120,000 (34.4 percent) from the Office of Emergency Planning.
[2] Reported as a conservative estimate.

The estimated $182,900 spent for care of hospitalized patients included approximately $29,400, or 16.1 percent for physicians' fees during hospitalization (table 2). The remaining $153,500, or 83.9 percent, was for other hospital charges. The physicians' fee estimate is based on current Medicare fees and assumes one hospital visit per day for each patient and one hospital consultation for each period of hospitalization.

Hospital financial records documented $132,300 (86.2 percent) of the $153,500 estimated for other hospital charges. This documented amount was completely accounted for by 130 patients (81.8 percent of the total 159 hospitalized patients) hospitalized in the five largest Dallas hospitals. Encephalitis and "other" hospitalized patients were first subdivided into the following categories indicating whether or not charges could be documented: (*a*) documented encephalitis patients, (*b*) remaining encephalitis patients, (*c*) documented "other" patients, and (*d*) remaining "other" patients. These four categories were found not statistically significant with respect to age and hospital stay compared with the total number of hospitalized patients (the four groups combined). Daily hospital charges for encephalitis patients with documented charges were used to estimate hospital charges for the remaining encephalitis patients. The same technique was used to estimate hospital charges for "other" patients where documented charges were unavailable. Documentation of charges was available for 108 of the 127 encephalitis patients and 22 of the 32 "other" patients. Table 3 presents hospital charges (excluding physicians' fees) for these 130 documented patients.

A survey of 39 hospitalized patients and all the 13 nonhospitalized patients was used to estimate physicians' visits and drug use before and after hospitalization (or during the course of illness for the nonhospitalized patients.) The sample of 39 hospitalized patients was found not statistically significant compared with the total hospitalized patients with respect to age and percentage composition between encephalitis and "other." Of these 39 patients, 16 (41 per-

Table 2. Days of hospitalization and estimated charges for patients, by classification of patients' illnesses

Classification	Number of patients	Days of hospitalization		Total estimated hospital charges			Per patient	
		Total	Per patient	Hospital	Physician	Per day	Hospital	Physician
Encephalitis	127	1, 858	14. 6	$136, 100	$24, 100	$86	$1, 072	$190
"Other"	32	364	11. 4	17, 400	5, 300	62	544	166
Total	159	2, 222	14. 0	153, 500	29, 400	82	966	184

Table 3. Documented charges [1] at 5 major Dallas hospitals

Hospital No.	Number of patients [2]	Days of hospitalization		Hospital charges		
		Total	Per patient	Total	Per day	Per patient
1	93	1, 296	13. 9	$92, 000	$71	$990
2	16	276	17. 3	18, 600	67	1, 160
3	10	153	15. 3	11, 300	74	1, 130
4	6	85	14. 2	6, 300	74	1, 050
5 [3]	6	91	15. 2	4, 100	45	680
Total	131	1, 901	14. 5	132, 300	70	1, 000

[1] Excluding physicians' fees.
[2] One patient who was hospitalized at two hospitals is considered as two patients for this tabulation.
[3] Federal hospital.

cent) had not visited a physician or clinic before their hospitalization, and 15 had made only one visit before hospital admission. Twenty-six of the 39 patients (66.7 percent) visited physicians no more than three times after discharge from the hospital.

If information as to physician usage was unknown, it was assumed that patients hospitalized at the major Dallas "city-county" hospital made clinic visits and all other hospitalized patients used private physicians' services. One prehospitalization and two posthospitalization visits were assumed in these instances. The following fees were assumed: (*a*) $8 per physician visit, and (*b*) $5 per clinic visit (based on average cost of $4.83 incurred by the major Dallas "city-county" hospital for total outpatient clinic operations). Based on the findings of the survey and these fee estimates, an estimated $3,100 was for physicians' fees.

The survey also indicated that drug use before and after hospitalization was not extensive. Sixteen medical records of a major Dallas hospital, selected by using a table of random numbers, supported this conclusion. Discharge orders on 10 of these records merely indicated "no meds." Based on these data, drug use amounted to a daily sum of $1 per patient, an amount arbitrarily chosen as being consistent with the low drug use noted.

To determine the total number of days involved (days of drug use before and after hospitalization), convalescent periods were assumed to equal a time period of 2½ times the interval from onset of illness to hospital discharge. A sample of 26 hospitalized encephalitis patients and three hospitalized "other" patients was surveyed to estimate the mean length of convalescence. Compared with the total number of hospitalized patients, this sample did not differ significantly with respect to age and length of hospital stay. The 26 encephalitis patients did not differ significantly from the three "other" patients with respect to the mean convalescent period. This sample consisted of only those patients available to give the needed information. Dates of onset of illness were obtained from NCDC epidemiologic data.

Based on these findings and assumptions, the cost of drugs outside the hospital for the 159 hospitalized and 13 nonhospitalized patients was estimated to be $6,300 (drug costs incurred during hospitalization are included in table 2).

A final part of treatment costs includes nursing home and nursing care services. The following fees were derived from discussions with Dallas nursing officials: (*a*) $5 per visit of nurses from the visiting nursing association, (*b*) $25.50 per 12-hour duty of licensed vocational nurses, and (*c*) $150 per month for nursing home service. Participating nursing organizations indicated the extent of services given. Nursing services could be identified with nine of the total 172 patients with confirmed or presumptive cases of SLE. From the information given, an estimated $3,800 was spent for nursing care.

Morbidity

As indicated earlier, earnings are used to measure morbidity and mortality losses. Earnings data for this study were obtained primarily from (*a*) Dallas hospital medical records, (*b*) the November 1965 "BLS Area Wage Survey" of the Dallas metropolitan area, and (*c*) Texas Employment Commission gross average hours and earnings figures. Medical records often included information on the occupation of patients.

The morbidity cost estimated in this analysis takes into consideration these instances of output loss: (*a*) shortrun productivity losses, (*b*) longrun productivity losses, and (*c*) productivity losses associated with home care.

Shortrun productivity losses refer to losses incurred by patients during their illness and convalescence. Of the total 172 patients, earnings lost could be identified for only 91 (83 hospitalized and 8 nonhospitalized). The remaining 81 were either children (16 years old or younger) or unemployed, welfare, or retired patients. Since the socioeconomic level of many residents is low in areas bordering the Trinity River (areas where the mosquito infection rates and the human case rates were highest during the epidemic), the low percentage of patients in an earning capacity (91 of 172 patients, or 52.9 percent) is not surprising. Consistent with Rice's methodology (*1*), the mean earnings of a domestic servant ($2,670) are used to estimate the value of housewife services. Total days lost because of illness are adjusted downward by

five-sevenths to estimate total working days lost. Unadjusted earnings figures are adjusted upward by a factor of 1.0776 to take into consideration wage supplements. Table 4 presents estimated shortrun morbidity losses.

Morbidity costs related to longrun residual effects are referred to here as longrun productivity losses. Medical investigators noted no significant residual effects attributable to the Dallas epidemic. Other followup studies of SLE epidemics have also indicated that recovery was generally uneventful (*5*, *6*). Therefore, no cost has been estimated for the related morbidity cost and the cost of institutional care needed.

Supportive treatment and care given by household members are additional instances of resources diverted from other uses. Cases can be cited where working members of a household were forced to remain at home to give care to another household member. Based on additional data from patient surveys already described, it is assumed that each patient received care by a household member for one-third of the days he convalesced at home. Using the value of women's foregone household production as the best available measure of productivity diverted because of home care, an estimate of $22,100 is the cost of productivity losses associated with home care. It is assumed that after discharge from the hospital patients received either nursing home care or care at home. An estimate of $2,670 was used for housewife-imputed earnings.

Table 4. Estimated shortrun morbidity losses

Patients	Number	Working days lost		Shortrun loss	
		Total	Per patient	Total	Per patient
Hospitalized	83	3,800	46	$58,500	$700
Nonhospitalized	8	70	9	2,200	280
Total	91	3,870	43	60,700	670

Mortality

To estimate epidemic-related mortality losses, future streams of gross earnings are discounted to approximate present value equivalents. A discount rate of 4 percent was used to maintain consistency with the methodology of most current economic analyses in the health field (*7–9*).

Assumptions and methodology were as follows:

1. Earnings figures are median earnings for the 83 patients used to estimate shortrun morbidity costs of hospitalized patients (women $2,676; men $3,720). These averages are approximations for the socioeconomic groups examined.

2. Earnings are assumed to remain constant over all years considered for analysis. Individuals are assumed to retain their employment status until age 70. Both age and sex were taken into consideration in estimating productivity losses.

3. Data from the 1964 "Vital Statistics of United States" are used to estimate survival probabilities (*10*).

4. Data from the 1966 "Statistical Abstract of the United States" are used to estimate labor force participation rates and housekeeping rates (percentage of women not in the labor force considered housewives). In the absence of labor force participation rates by year, 5- and 10-year age groupings are used for the appropriate rates. It is assumed that a housekeeping rate of 50 percent is conservative. Similar to Rice's method (*1*), no allowance is made for unemployment.

NCDC epidemiologists classified 20 deaths as attributable to encephalitis. Two other deaths occurred in late convalescence, and four others were attributed to encephalitis with other prominent causes. Based on information available from medical records and death certificates, five persons who died from encephalitis, one who died in late convalescence, and one who died from encephalitis with other possible causes were either employed or in housewife status before becoming ill. It is assumed that the epidemic was responsible for all the mortality losses associated with these seven deaths.

In addition to productivity loss, another mortality loss estimated was that of burial cost loss. Holtmann and Ridker (*11*) argued that delays of death (and thus delays of burial expenditures) result in an additional economic return: "the difference between the present cost of burial and the present value of the expected

future cost of burial." Their estimated burial cost losses by age and sex are used as estimates of these losses related to the Dallas epidemic.

As a result of these assumptions and methods, a cost of $169,100 was estimated for mortality losses (table 5). Of this amount, $159,000 was estimated to be the discounted future earnings lost due to premature death. The remaining $10,100 was an estimate of additional burial costs incurred due to premature death.

Broader Impact on the Community

The epidemic may have had a broader impact upon the Dallas community. Selected indices which might reflect changes in either residential or nonresidential activity were examined. Highway usage and convention, theater, and school attendance suggested that the impact on the overall Dallas economy was relatively mild. This appears consistent with findings in Houston after the St. Louis encephalitis epidemic in that city in 1964 (*12*).

Although numerous Dallas authorities received calls from out-of-State residents inquiring about the advisability of traveling to Dallas, convention and tourist business did not appear to be significantly affected by the epidemic's presence. Major hotels and motels related only a few instances of reduced occupancy or convention attendance, and, in view of the August 1966 airline strike, it is extremely speculative to attribute these to the epidemic. Conventions that did experience attendance changes were generally those in the last 2 weeks of August and the first week of September (coinciding with the aerial spraying period, when national publicity was most intensive and several major airlines were on strike). On the basis of "vehicle per day" data tabulated by permanent highway counters, traffic entering Dallas during the epidemic period was consistent with normal expectations for July 1 to September 15.

Because of the aerial spraying operations, the outdoor activities of residents may have been altered somewhat. One documented instance of this impact was the decreased attendance at outdoor theaters (particularly at drive-in theaters located in mosquito-problem areas during the epidemic). During early fall 1966, a number of legal suits were filed by Dallas residents against the city for losses claimed to have arisen from spraying operations.

University enrollment and attendance during the epidemic period did not appear to differ from expectations. An examination of retail sales and sales of produce and fresh fruit during August 1966 indicated sales par with expectations and, in some instances, actually exceeding projected estimates.

In sum, only isolated instances indicate possible epidemic-related impact on the community. Additional information on this aspect of the study can be obtained from me.

Discussion

This paper does not purport to be a comprehensive economic analysis of an epidemic occurrence. To have accomplished this end would have required greater depth than the direct and straightforward approach adopted. On the contrary, this paper was premised on the following objectives: (*a*) to present a simple economic measure of the magnitude of the problem, (*b*) to indicate data inadequacies in need of being corrected to permit more comprehensive eco-

Table 5. Estimated mortality costs

Deaths	Productivity loss			Burial cost loss		
	Number persons [1]	Total loss	Loss per person	Number persons	Total loss	Loss per person
Attributed to encephalitis	5	$58, 500	[2] $11, 700	20	$7, 100	[2] $355
In late convalescence	1	33, 400	33, 400	2	1, 000	500
Attributed to encephalitis with other prominent causes	1	67, 100	67, 100	4	2, 000	500
Total	7	159, 000	22, 700	26	10, 100	388

[1] Only seven persons identified as being in either employment or housewife status before death.
[2] Higher average age in this group accounts for lower loss per person and lower average burial cost loss.

nomic studies, and (*c*) to stimulate greater interest in the growing discipline of health economics.

Consistent with methodology presented by Rice (*1*), itemization of direct and indirect costs incurred as a result of the epidemic constitutes a basic approach to estimating the economic magnitude of the epidemic. If Dallas had had an active encephalitis early-warning system before late July 1966 and if the epidemic had not occurred, costs enumerated in this paper would have represented benefits attributable to the prevention program. In considering prevention programs and their subsequent funding, the health administrator must be cognizant of the resulting economic benefits derived. This does not mean to imply that noneconomic aspects of the problem should be ignored, nor does it imply that health administrators' decisions be dictated solely by economic considerations. An economic comparison of costs and benefits of a respective program does, however, enable the administrator to determine economically whether or not the program represents an efficient allocation of resources. This additional perspective has merit in widening the relevant considerations confronting the decision maker.

To permit further economic studies of health problems, there is a critical need for increased data which are meaningful for analysis and evaluation. The empirical investigation undertaken for this study uncovered considerable gaps in relevant information. For example, data were seriously lacking with respect to a patient's course of illness after hospitalization. Data-gathering activities used in this study closely resembled investigations undertaken by epidemiologists. An extensive amount of time was directed to conversing with patients and their physicians (using standard protocols), examining numerous medical records, and discussing the epidemic with numerous "firsthand" observers. If more effective economic studies are indeed desired, health administrators must be alerted to the need for relevant data and should give greater attention to funding activities in this direction.

I have attempted to further illustrate the use of economics in the health field. Hopefully, as administrators become more aware of the usefulness of economics in decision making and as more appropriate data are gathered, comprehensive analyses using economic techniques will become more widespread.

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